Virtual Guide Dog: the Next Generation Pedestrian Signal for the Visually Impaired

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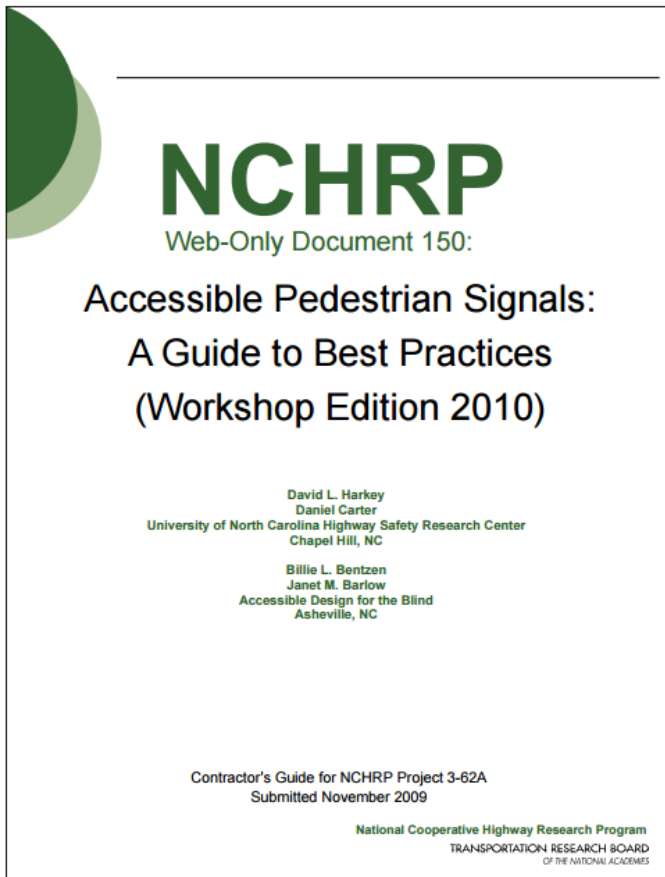
ITS Resource Center

New Jersey Institute of Technology

Outline

- Motivation
- VGD Framework
- Proof-of-concept Test
- Next Step

Motivation

NCHRP
Web-Only Document 150:

Accessible Pedestrian Signals:
A Guide to Best Practices
(Workshop Edition 2010)

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Contractor's Guide for NCHRP Project 3-62A
Submitted November 2009

National Cooperative Highway Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Appendix D: Understanding How Blind Pedestrians Cross at Signalized Intersections

1. **Locating the Street :**
    → Am I around an intersection?
2. **Street Recognition**
    → Which street to cross?
3. **Intersection Assessment**
    → How complicate the intersection?
4. **Cross the Roadway**
    → Am I OK to cross?

Virtual Guide Dog: Components

Pedestrian

GPS & Compass

GPS

Wifi

Bluetooth or WiFi

Wireless Communications
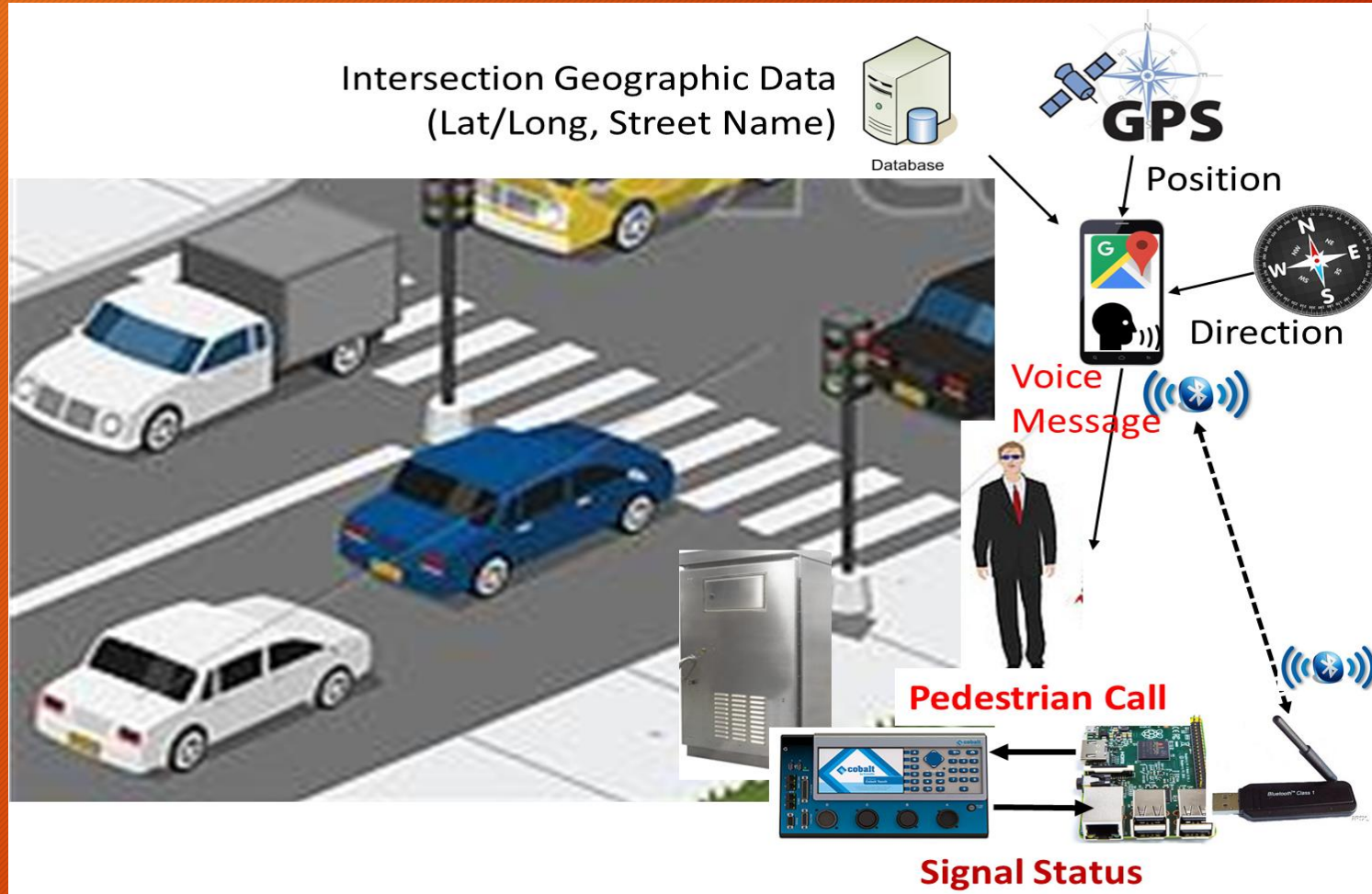
Signal Controller

Mini PC (Raspberry Pi)

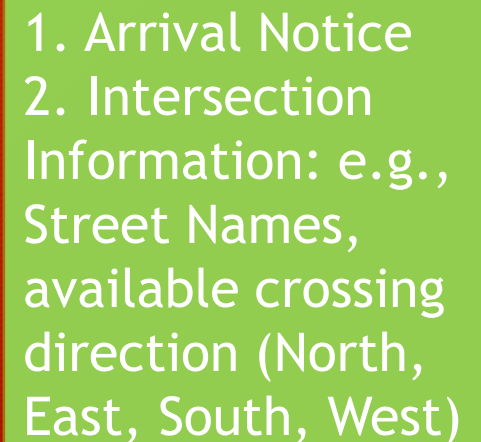Intersection Bluetooth or WiFi

Virtual Guide Dog: Architecture

Virtual Guide Dog: Technologies Integrated

- Real-time geo-positioning using GPS, compass and Wi-fi
- Voice message/notification
- Touch control user interface
- Traffic signal control using NTCIP
- Bluetooth-based short-range communications

Virtual Guide Dog: How it works

- Step 0 : User Registration
  - To identify qualified users and prevent potential misuse of the application by unqualified users
  - Register device information to detect qualified users: e.g., Bluetooth/WiFi MAC address, UUID, etc.

Virtual Guide Dog: How it works

Step 1

App checks current position (Lat/Long)

Within Intersection Area (e.g. 30ft)?

1-second update interval

N

Y

Step 2

Voice Notification to the User

Intersection Sensor WiFi

1. Arrival Notice
2. Intersection Information: e.g., Street Names, available crossing direction (North, East, South, West)

Virtual Guide Dog: How it works

Step 3

User Inputs for Crossing

1. Through Voice Message
2. Screen Tapping. e.g.,
   - Single : North/South
   - Double : East/West
   - Tripple : …

Step 4

Check Yaw (Heading)

Face to the correct direction?

Y

N

Voice Message "Keep Turning"

Virtual Guide Dog: How it works

Step 5

Connect to Controller-side Device

Step 6

Place a Pedestrian Call

Step 7

Monitor Controller Data

1. Option 1: Bluetooth Pairing
2. Option 2: WiFi Ad-Hoc Network
3. Option 3: Cellular Network (3G,4G/LTE)

NTCIP

Virtual Guide Dog: How it works

Step 7

Step 8

Monitor Controller Data → Pedestrian Signal On? —Y→ Voice Message "Safe to Cross" →

N (loops back to Monitor Controller Data)

Virtual Guide Dog : How it works

Check Position (Lat/Lon coordinate)

Complete Crossing?

Y → **Voice Message "Crossing Done"**

N → **Voice Message "Keep Crossing"**
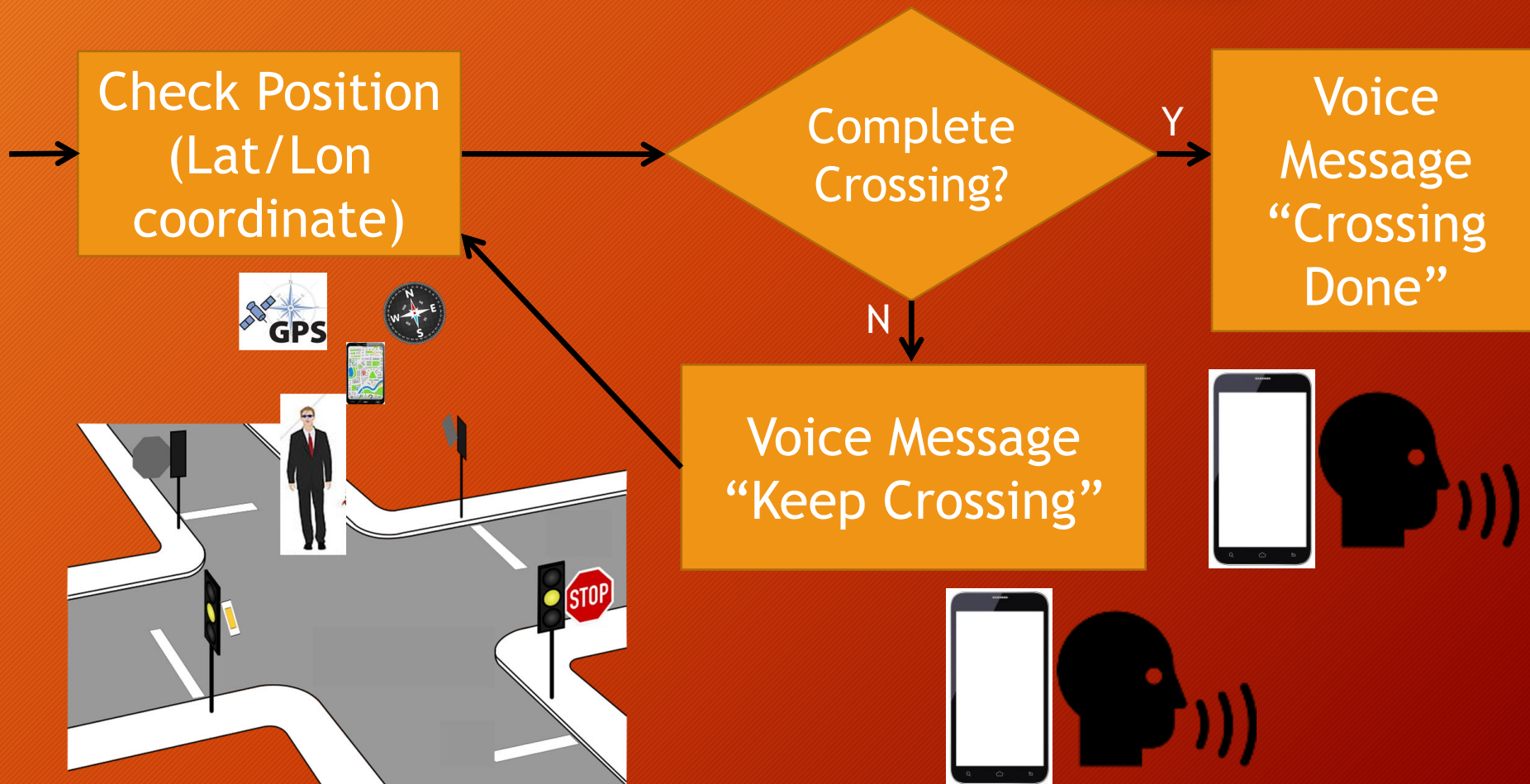
Proof-of-Concept Test

- VGD Mobile Application
- Hardware-Human-in-the-loop Simulation (HHILS)-based Test
  - Actual controller
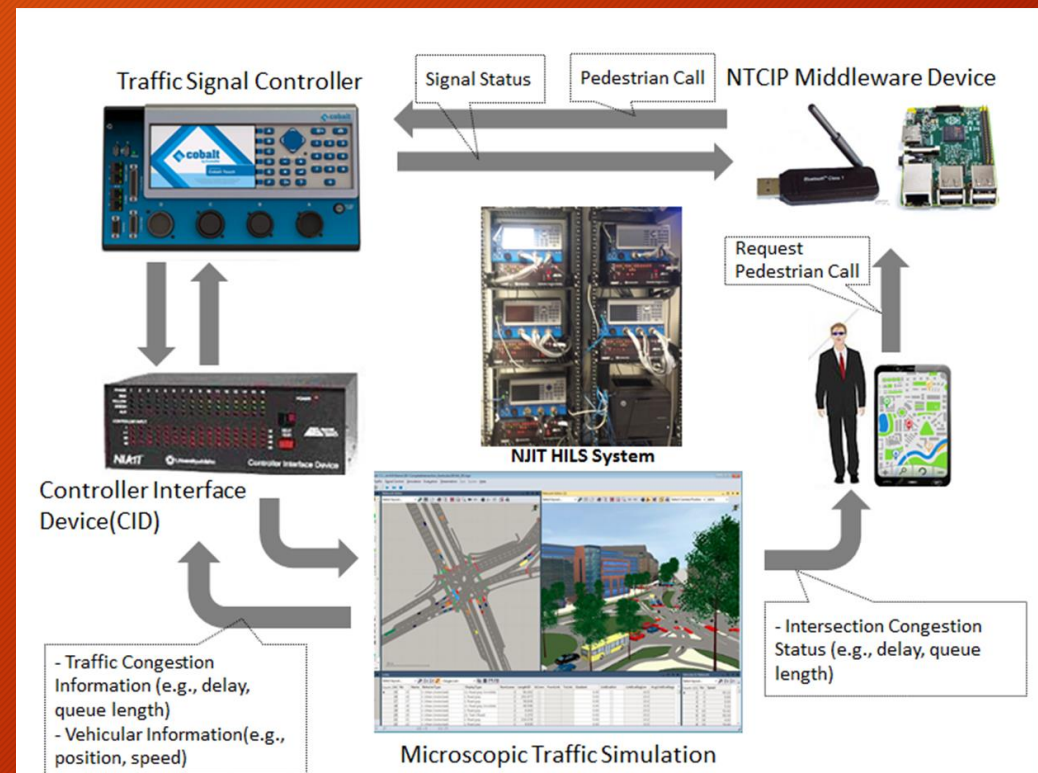 - Pedestrian with mobile app
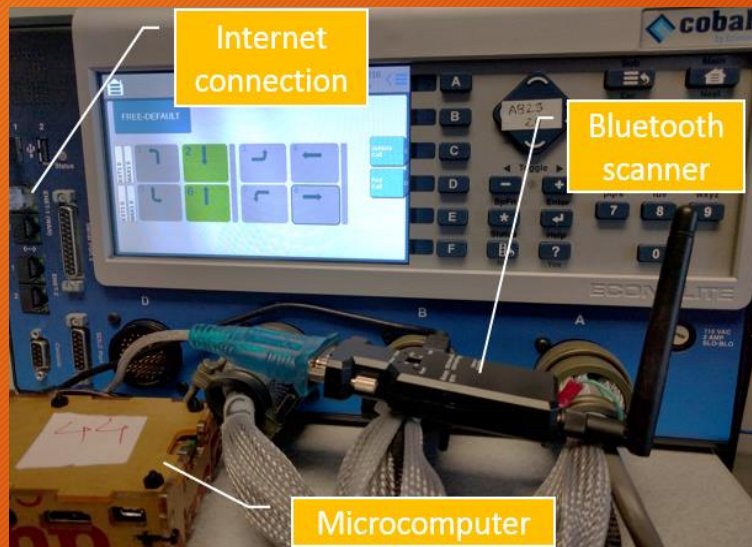 - Traffic simulation

Proof-of-Concept Test
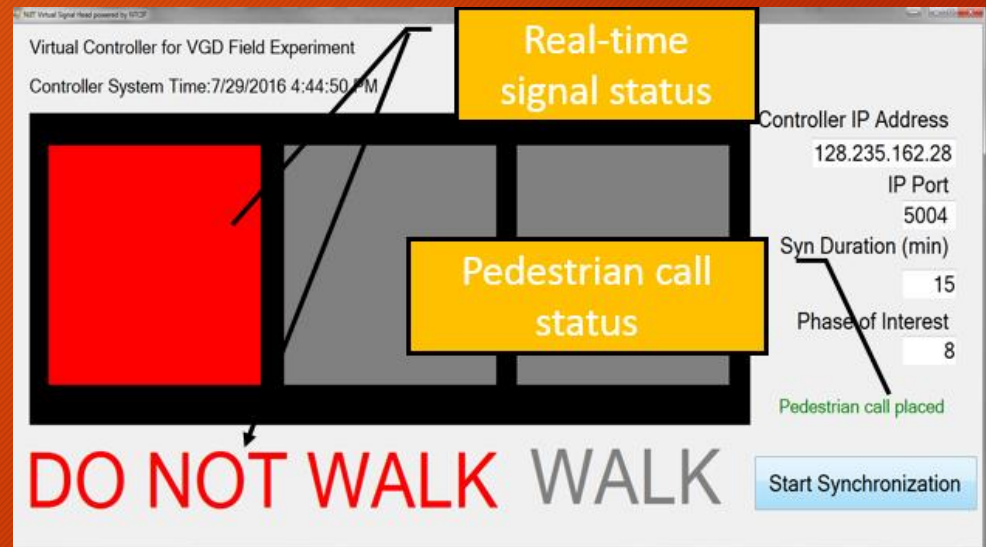
- Hardware-Human-in-the-loop Simulation (HHILS)
    - Enabling risk-free App development
    - Examine the impacts on intersection and street under various conditions

Traffic Signal Controller

Signal Status

Pedestrian Call

NTCIP Middleware Device

Request Pedestrian Call

NJIT HILS System

Controller Interface Device(CID)

- Traffic Congestion Information (e.g., delay, queue length)
- Vehicular Information(e.g., position, speed)

Microscopic Traffic Simulation

- Intersection Congestion Status (e.g., delay, queue length)

Proof-of-Concept Test

Signal Controller Retrofitting

Virtual Controller Replicated by NTCIP Protocol

➢ HHILS is used for the testing due to safety concerns
➢ Microcomputer combined with Bluetooth scanner to receive calls and process requests
➢ The primary function for the virtual signal head is to display what is showing on the signal controller located in ITSRC Lab.

Proof-of-concept Test
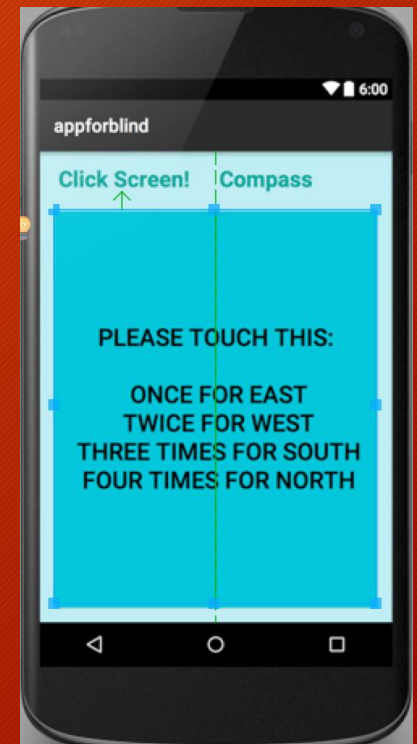
- ➢ Five reference points were selected
- ➢ Central Ave. & Lock St. in Newark, NJ
- ➢ Two non-VI test participants
- ➢ Virtual controller synchronized with controller located in ITSRC Lab

Conclusions

➢ The VGD application could be an attractive alternative for conventional Accessible Pedestrian Signal(APS) for VIs.

➢ The cost of implementing VGD is only a fraction of that of conventional APSs.

➢ Smartphone's GPS position accuracy is often insufficient to ensure the safety of the VIs.

Position Accuracy
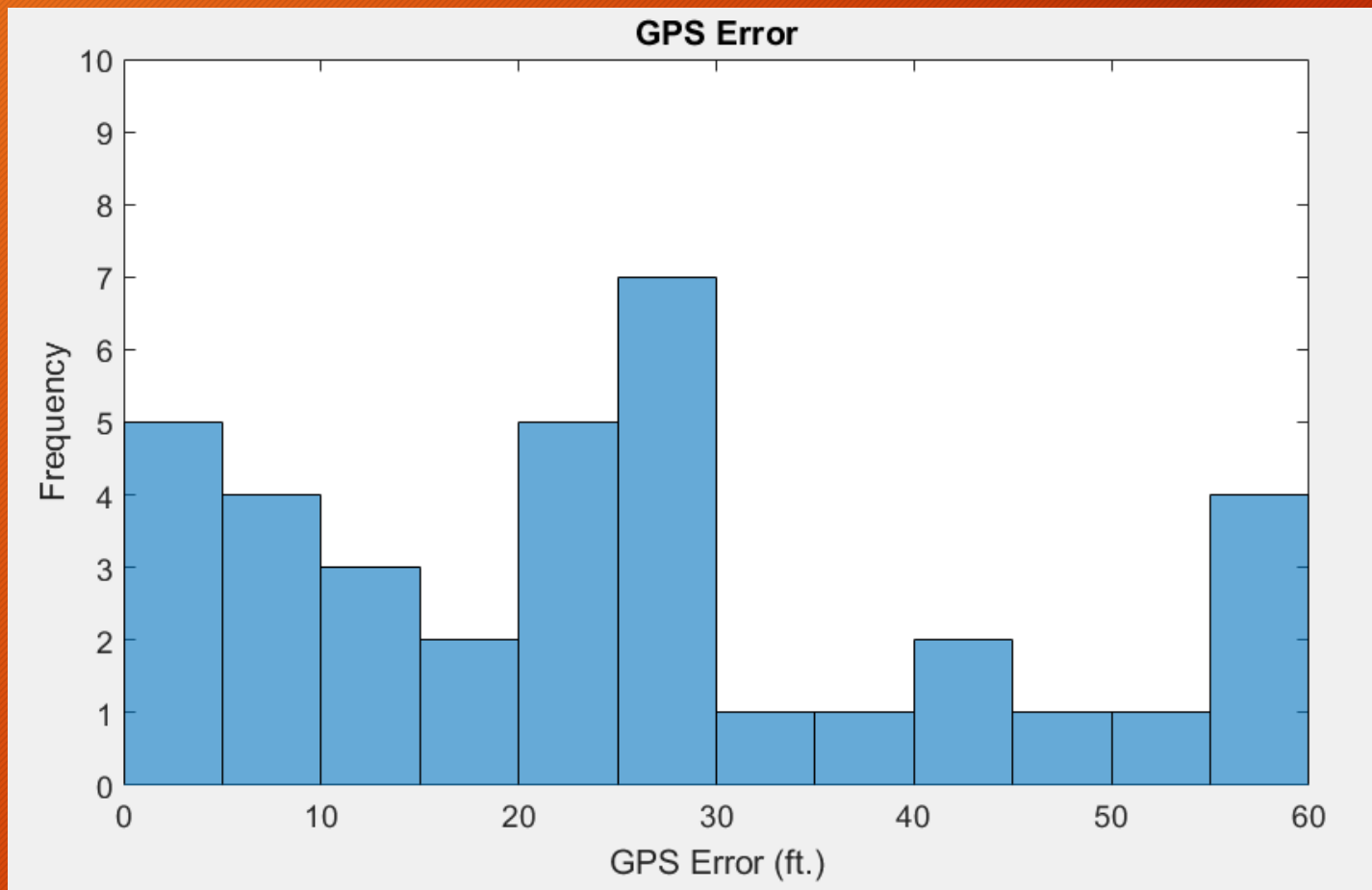
Position Accuracy

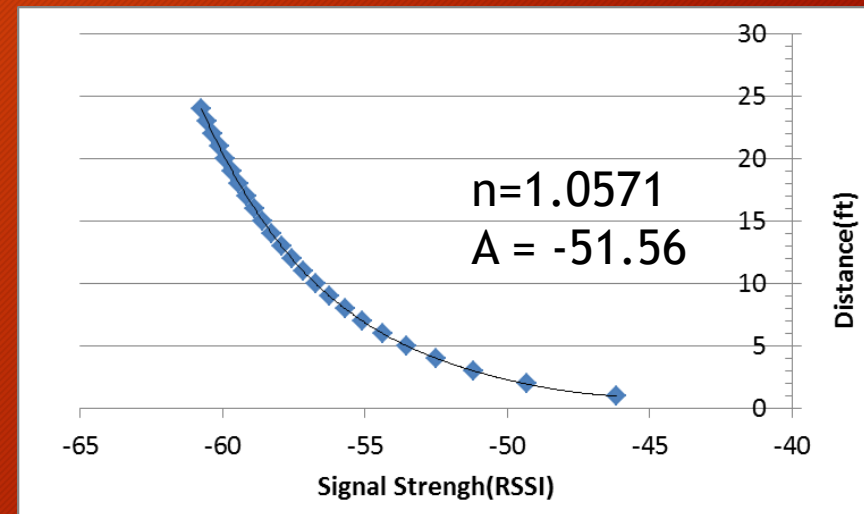- Distance estimation technique using Wi-Fi signal strength (Pass Loss Equation)
  - RSSI = nlog(d) + A
    - RSSI : Received Signal Strength Indicator (dBm)
    - d : distance (ft)
    - A : reference RSSI
    - n : Coefficient

n=1.0571
A = -51.56

Next Step

- Improve the accuracy of real-time position information
- Conduct a field test at actual intersections (e.g., next to nursing homes or hospitals)
  - Deploy sensors, devices, and mobile App
  - Perform mock experiments to evaluate the effectiveness of the VGD application
  - Need a collaboration with municipality